An Observational Examination of Supercell and Squall Line Thunderstorm Interactions

Kevin M. Wagner and Adam J. French

South Dakota School of Mines and Technology – Atmospheric and Environmental Sciences Program

Introduction

- **Motivation:** Widespread severe weather outbreaks often contain multiple storm organizations, with supercells and squall lines generally producing most of the severe weather hazards. It is unclear, however what effect the presence of neighboring convective storms may have on convective storm intensity and severity.
- **Goal:** This project seeks to address the question of *how does a squall line affect the structure and intensity of a nearby supercell thunderstorm* by using radar data to identify common changes to the structure and intensity of the supercell as a squall line approaches.
- **Hypothesis:** Squall line-generated perturbations to the local environment will lead to changes in supercell structure including increasing low-level rotation, and increases in metrics related to updraft strength including maximum estimated hail size and echo top height.

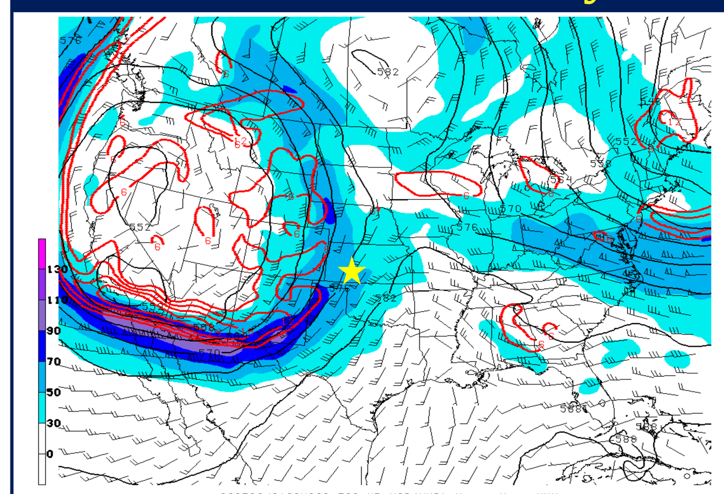
Previous Research

- A number of past studies have documented changes in the intensity and structure of isolated storms as they approach a squall line or bow echo. This includes increasing echo size and radar reflectivity factor (Przybylinski 1995), increases in low-level storm rotation, and changes in the type and frequency of severe weather reports (French and Parker 2012).
- Recent observations by Bryan and Parker (2010) documented the environmental evolution ahead of an approaching squall line, including changes to vertical wind shear, CAPE, CIN, and precipitable water; parameters that are well known to affect supercell structure and organization.
- This past work suggests that the presence of a nearby squall line may be sufficient to alter supercell structure and intensity, even in cases where the two storms do not merge into one system.

Methodology

- Obtained Level-II WSR-88D data from NCDC archives
- Input radar data in Warning Decision Support System – Integrated Information (WDSS-II) software and converted to netcdf format, dealiased data, and performed quality control.
- Grid Analysis & Display System (GrADS) used for display and analysis

23-24 May 2008 Case



- Deep 500mb trough over western CONUS (Ω block)
- Strong >80 kt jet
- Area of dCVA support synoptic rising motion

Figure 1: 23 May 2100 UTC RUC 500mb heights, winds, & vorticity

- Low pressure system over CO/KS/OK
- Ample moisture advecting from the Gulf of Mexico in the warm sector
- Storms form along dryline extending across KS/OK

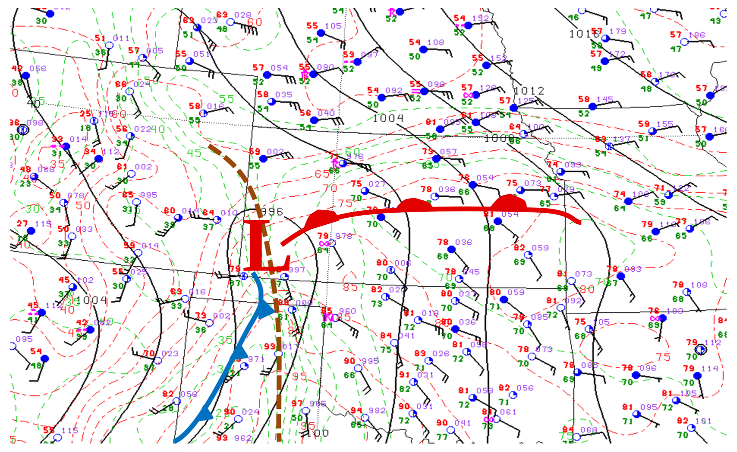


Figure 2: 24 May 0000 UTC Surface obs & RUC MSLP, temp, & dewpoints

24 May 2008 KDDC WSR-88D Radar 3km AGL

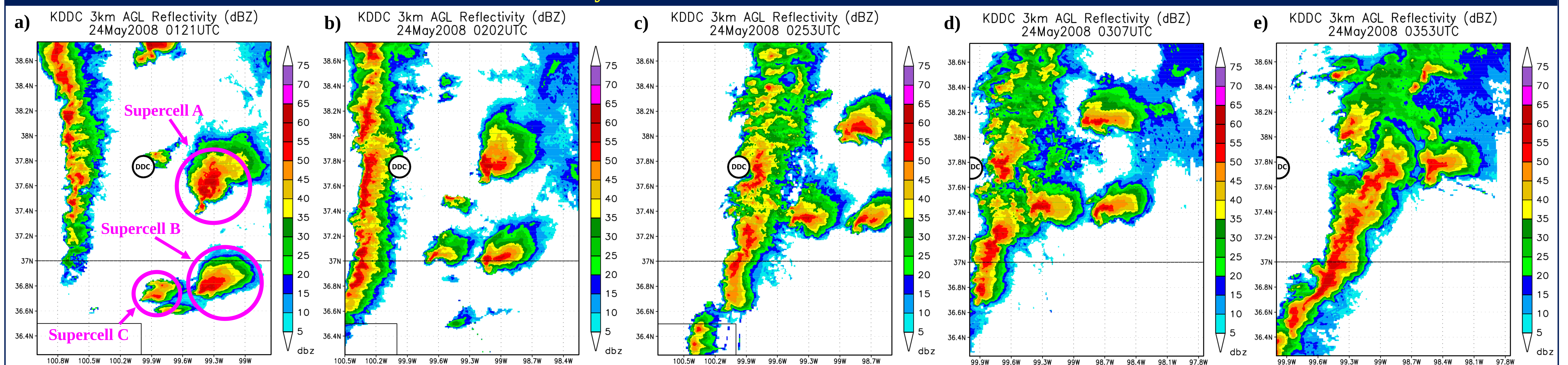


Figure 3: 3 km AGL Reflectivity from Dodge City, Kansas WSR-88D from (a) 0121UTC, (b) 0202UTC, (c) 0253UTC, (d) 0307UTC, and (e) 0353UTC on 24 May 2008. Supercell A was in its mature stage as the squall line forms and as the squall line approached, its intensity decreased along with the northern portion of the squall line by 0253UTC. Supercell B was in the developing stage when the squall line formed. As the squall line approached, the intensities fluctuated as it transition into the dissipating stage, but steadily increased by the time of the merger at 0421UTC. Supercell C formed after the squall developed. As the squall line approached, it was entering the mature stage and was increasing in intensity as it merged by 0307UTC. After the last merger, the line evolved into a bow echo..

Radar Derived Products

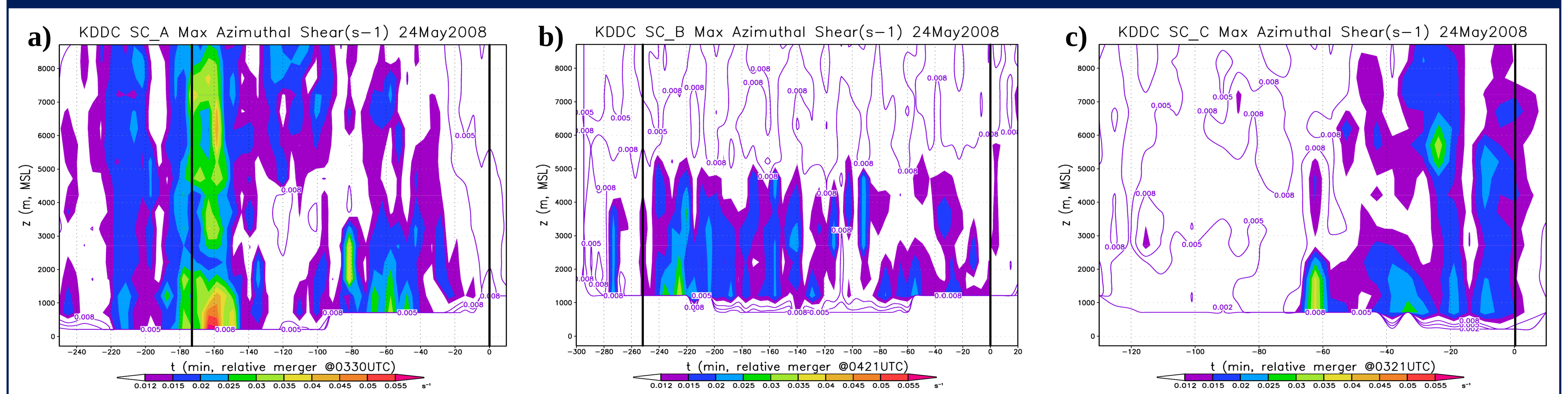


Figure 4: Time vs. height plots of maximum azimuthal shear (s^{-1}) associated with 24 May 2008 isolated supercells for (a) Supercell A, (b) Supercell B, and (c) Supercell C. Time (min) is relative to the supercell merging with the squall line with the line at t=0 indicating the merger for each supercell at (a) 0330UTC, (b) 0321UTC, and (c) 0421UTC. The lines at (a,) t= -166 and (b) t= -254 denotes the formation of the squall line by 0044UTC.

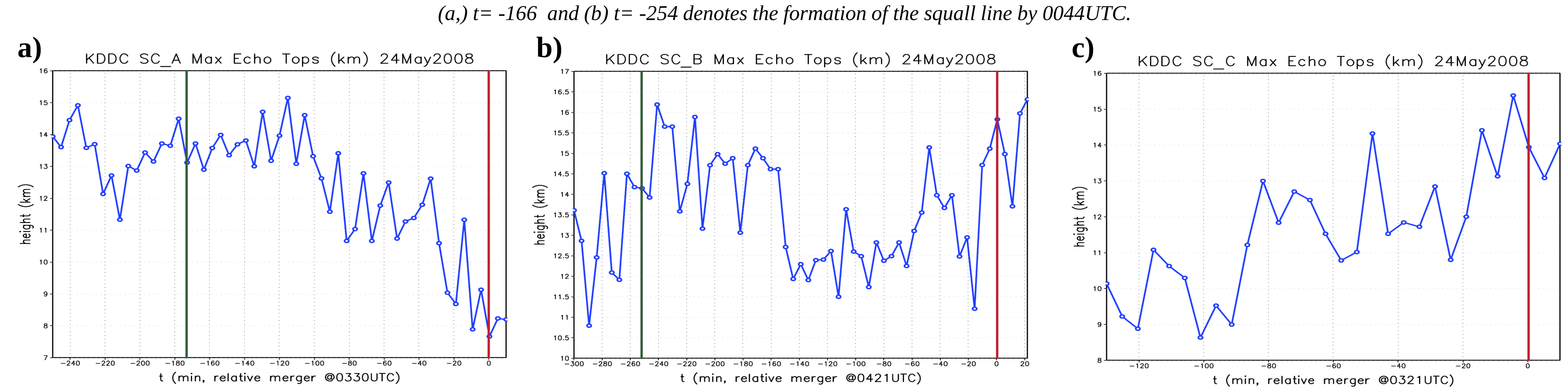


Figure 5: Time series of maximum 50 dBZ echo tops for 24 May 2008 (a) Supercell A, (b) Supercell B, and (c) Supercell C. Time is in a merger relative framework as in Figure 4.

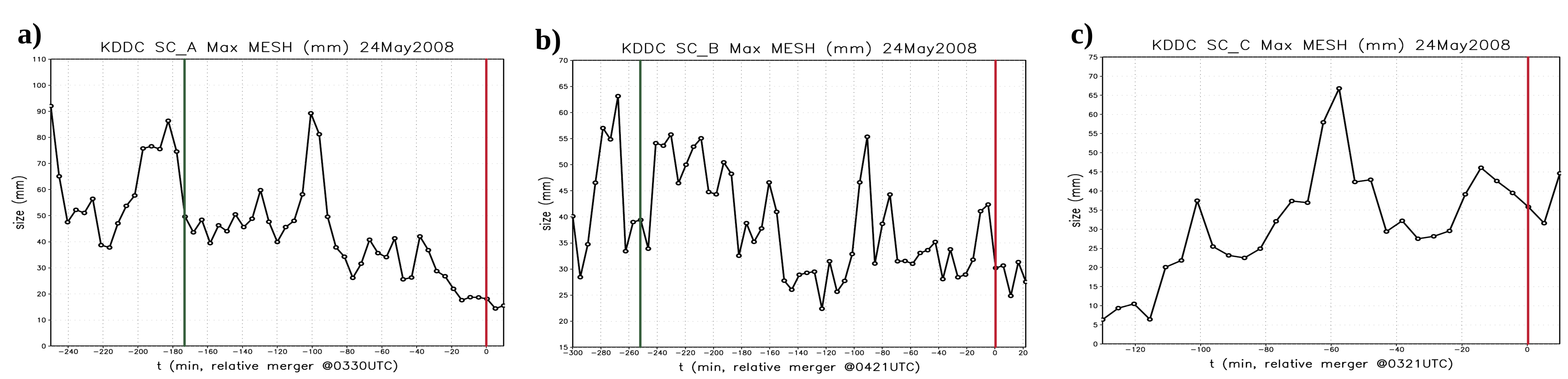


Figure 6: Time series of maximum value of maximum estimated size of hail (MESH, mm) associated with 24 May 2008 (a) Supercell A, (b) Supercell B, and (c) Supercell C. Time is in a merger relative framework as in Figure 4

Results

- Supercells A and B are classified as long-lived (≥4h), while Supercell C is categorized as a short-lived (≤2h)
- Each supercell is observed in a different stage in its lifecycle when the squall line develops and upon merger
- Azimuthal shear initially decreases as the squall line approaches for supercells A and B, but then increases immediately prior to the merger in all three cases
- Echo top time series for supercell B and C shows a general strengthening trend, while supercell A shows a weakening trend
- Supercell A and C MESH time series share similar trends to the corresponding echo top time series, except for supercell B, where the MESH has a noticeable decreasing trend
- Supercell A along with the northern portion of the squall line's weakening trend may be attributed to the southern two supercells cutting it off from the more favorable environment
- Model simulations of this event shows similar trends in intensity and rotation for the supercells
- Radar attenuation may be a source of error

Future Research

- Use this analysis framework on other cases to identify any common features in the structural evolution of supercells
- Cases from 2012-2015 will be utilized to incorporate the use Dual-Pol radar products into the conceptual model
- Categorize the different types of events based on number of supercells and type of squall line (i.e. bow echo, cold front, etc.)
- Utilize surface and upper air observations to identify the presence of squall line generate perturbations
- Continue to compare model simulations and work on creating a feasible operational forecasting procedure

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